2.1. Networks including the Internet

- Networking devices are interconnected devices that allow a fast means of data transmission within the network.
- Networking benefits:
  - File sharing - you can easily share data between different interconnected devices
  - Resource sharing - using network-connected output devices like printers, or can share the same software within the network
  - Higher storage - can store files in network-connected storage mediums.
- LAN(Local Area Network) vs. WAN(Wide Area Network)

LAN	WAN
Network that connects devices within a small geographical area	Network that connects devices within a larger geographical area
Only private ownership	Private or public ownership
Transmission medium: twisted pair cable, coaxial cable or Wi-Fi	Transmission medium: PSTN or satellite link
Higher data transfer rate	Lower data transfer rate
Lesser congestion	Higher congestion

- Client-server Model
  - Server based network: dedicated server provides an application (administration of users, security and resources) for the client computer to utilize
- Client-server Applications
  - Printer: manages print jobs from client computers
  - File Sharing: the client accesses software and user's data files stored on the server
  - Proxy server
  - Email server: for sending, receiving & storing emails
  - Database server: manages DBMS
  - Domain controller server
    - Management of user accounts (IDs & passwords)
    - Client sends login request to server which processes and grants request if user ID & password recognized

Thin Clients	Thick Clients
A client that solely runs on the resources provided by the server and has no local storage	An independent client that does not require the server to run
Only provides input and receives output; processing done by server	Thick client processes most of the application
Smaller purchase cost: expensive, demanding hardware is not required	Can function even if no server is connected (works offline)
Improved security: cannot run unauthorized, harmful software	No lag related to network problems

- Peer-to-peer network model (P2P)
  - Decentralised network where each connected computer stores data and operates independently as a 'peer', and can act as both a client & server.
  - Applications: Internet and Ad hoc networks
- Client-server vs. Peer-to-peer models

| Client-server	Peer-to-peer
Centralized backup	Lesser initial setup cost
Files & resources centralized in server: prevents illegal resource usage	Lesser network traffic: each peer can simultaneously receive data from different sources
Improved security: files are stored on central server which would be regularly scanned for malware	Can work even if a device goes down, but Client-server model can't work if server goes down

- Network Topologies
  - Bus
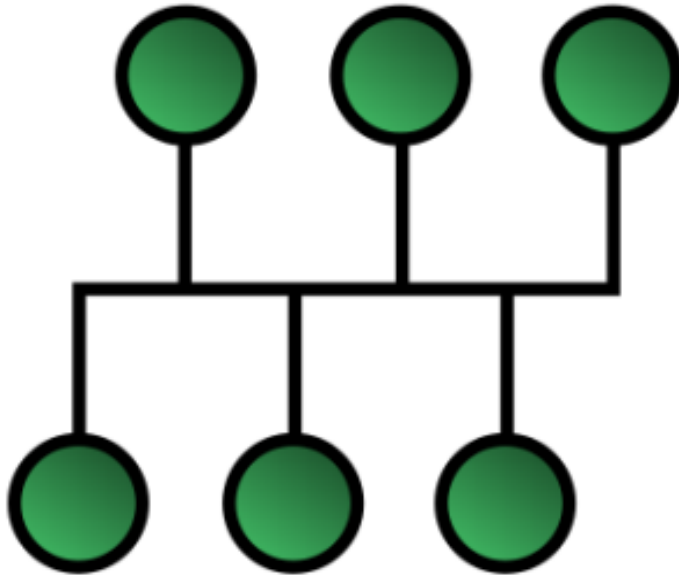
- Single line (bus) connecting all devices with terminators at each end.
- Other computers can read the data being sent from one to another computer.

- Unsuitable for heavy traffic since collisions occur.
- Star
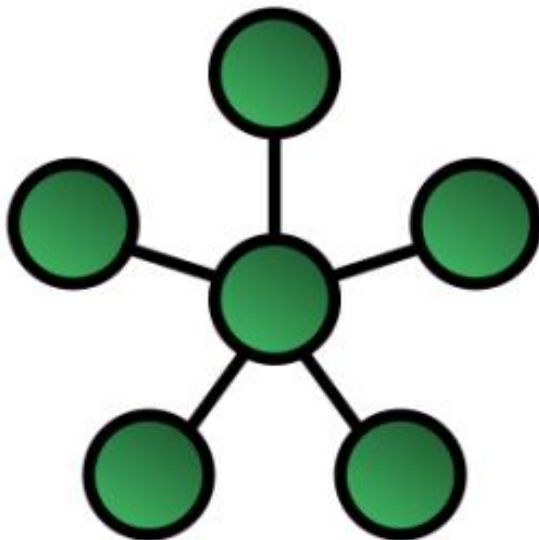
- Consists of a central server ('Switch') and all other computers connected with a dedicated connection to each, hence server can send packets to different devices simultaneously and bi-directionally.
- No collisions possible.

- Mesh
  - Network setup where every device (node) is directly interconnected to the each of the other devices (nodes)
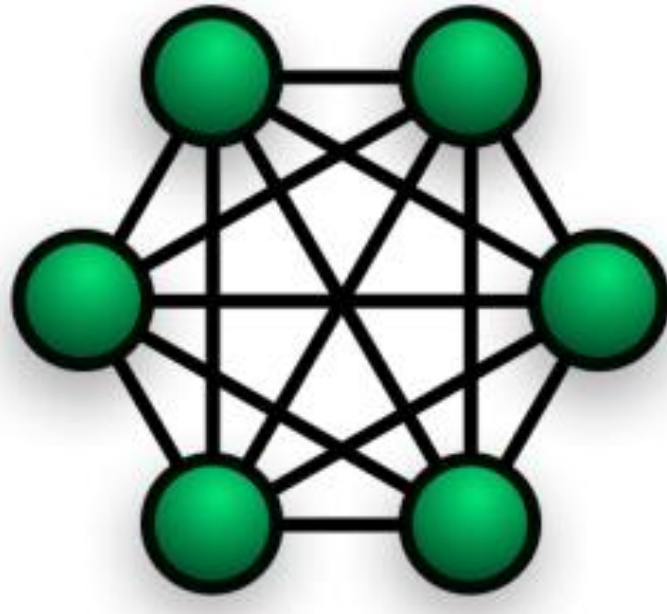
  - It is commonly used for wireless networks (such as the Internet), via the mesh connection of routers
- Hybrid
  - Combination of two or more topologies.
  - E.g. when there is a connection between 2 or more LANs of different topologies
- Wired Networks: use (copper (twisted-pair cable or coaxial cable) or fibre-optic) cables connected to an Ethernet port on the network router

	Benefits	Drawbacks
Copper Cable	Less expensive and easier to install FlexibleEasier to make terminations	Doesn't perform well with small charges.Affected by electromagnetism
Fiber-Optic Cables	Greater bandwidthImproved security Lightweight: easy to installLess signal boosting required; used in long distance comm.	Needs expensive optical transmitters and receivers.

- Wireless Networks: use radio waves (including WiFi), microwaves, satellites to connect devices to networks without cables.

	Benefits	Drawbacks
Radio waves	Can travel over large distances since they have largest range of wavelengthRelatively inexpensive.Used for TV signals & mobile phone comms.	Low frequency so transmits less data at one time.Affected by radio stations with similar frequency
Micro-waves	Larger bandwidth, can transfer more data at a time	Emitting towers expensive to build Physical obstacles can interfere
Satellites	Cheap with long distanceUsed for Satellite phones, satellite radio broadcast	Easy to interfereExpensive set up

- Ethernet
  - Most common wired medium of transmission, that can be used to transfer data between LANs or WANs
  - Usually used in bus topology; since all data travelled on a single wire there is a possibility of data corruption by the "collision" of signals
  - This collision is prevented by the CSMA/CD (Carrier Sense Multiple Access Collision Detection) method:
    - Before transmitting, device checks if channel is busy
    - If busy, device calculates a random wait time and waits that time, after which it begins transmission
    - Then during transmission, the device listens for other devices also beginning transmission
    - If collision, transmission is aborted and both devices wait different random times, then tried again
- Bit Streaming
  - Sequence of digital signals (bits) transferred over a communication path at high speeds
  - Requires a fast broadband connection and some form of buffers (short-term memory)
  - Bits arrive in the same order they are sent

- Bit rate: number of bits transmitted per second
- Two methods of bit streaming:

Real-time	On-demand
Event captured live via video camera that is connected to a computer	Existing digital files converted to encoded bit-streaming format for broadcasting on the internet by uploading to a dedicated server
Video signal converted to an encoded streaming video signal	A link for encoded video is placed on website and the user clicks on link to view encoded streaming video
Encoded video signal uploaded from computer to a dedicated streaming server via cables or high-speed wireless internet connection	The data is streamed to a buffer in user's computer and the buffer stops the video from being paused as the bits are streamed
Server then sends live images to all users requesting it as a real-time video	As the buffer is emptied, it's filled again thus providing continuous viewing
Cannot be paused, fast-forwarded, etc.	Can be paused, fast-forwarded, etc.

- Importance of high broadband speed / bit-rate
  - User has to download and display bits at same time
  - If media is of higher quality, then higher broadband speed needed since each "frame" is of a larger size
  - Real-time needs faster broadband speeds as compared to on-demand, since there are a greater number of users simultaneously requesting same data
- Cloud Computing
  - Refers to the on-demand provision of computing services through the internet
  - Services provided include
    - Infrastructure: Storage capacity and higher processing power
    - Platform: Software, testing & debugging resources
  - Public cloud vs. Private cloud

Public cloud	private cloud
3rd-party cloud service provider grants access to multiple parties, accessible via a browser	A private cloud is owned by one organization and is not shared with any other organization
Cloud service provider owns, develops and manages the public cloud through large server farms	The private cloud can either be created and maintained by the organization itself or it can outsource these tasks to a third-party

- Benefits and drawbacks of cloud computing

benefits	drawback
Relatively less technical knowledge required and easy to implement	Cannot access the resources/data stored on the cloud, if there are bandwidth issues
Flexibility: Cloud Can Be Scaled To Match The Organization's Growth	Poor data privacy, since there may be data leakage in the multi-tenant architecture (public clouds)

- World Wide Web (WWW)
  - Collection of web pages stored on websites
  - Protocols are used to transmit data across the WWW
- Internet (Interconnected network)
  - Massive, open network of networks
  - Uses TCP/IP protocol, which uses IP addresses to identify devices connected to the internet
  - Access provided by Internet Service Provider
  - Communication used: wired, radio and satellite
- Router in a network
  - Connects two networks together which may operate on different protocols
  - Allows internal connections between LANs OR allows external connection from the main LAN to a WAN
  - Router acts as gateway & firewall
  - Usually will be attached to server or switch in a LAN
  - Router translates private IP addresses to public IP addresses AND vice versa.
- LAN-supporting hardware
  - Switch: Connected to all devices in a LAN and can simultaneously broadcast information to all devices
  - Server: device/software provides specific function for computers in the network
  - Network Interface Card (NIC)
    - Provides each device (an end-system) in the wired LAN with a unique (MAC) address to uniquely identify it on the network
    - Allows each individual device to connect to network
  - Wireless Network Interface Card (WNIC): Provides each end-system of a wireless (WiFi) LAN a unique network address to identify it.
  - Wireless Access Points (WAP):
    - Allows devices to connect to the LAN via WiFi (wireless radio communication) instead of using a cable
    - Usually built into router
  - Cables: A wired transmission medium that allows communication in wired networks
  - Bridge
    - Connects two LANs which work use the same protocol, which can be two segments of the same network
    - Stores network addresses for all devices (end-systems) between the 2 networks
    - A bridge looks for the receiving device before it sends the message.

- Repeater
  - Connects two cables
  - regenerates the sent data signal over the same network before the signal weakens (attenuation) to prevent it from being corrupted
- Internet-supporting hardware
  - Modems
    - Allows a device to connect to the Internet via a telephone line.
    - A transmitter uses a modem to convert digital signals (from the transmitting device) to analogue signals that are then sent down the telephone line.
    - A receiver uses a modem on the other end to convert the analogue signals to digital signals so the receiving device can understand the data.
  - PSTN (Public Switched Telephone Network)
    - Refers to all telephone networks
    - Channel used between 2 endpoints for the call duration via circuit switching
    - Lines active even during power outage
    - Bi-directional communication
  - Dedicated lines
    - Telecommunication path between endpoints
    - Not shared with multiple users; it's bought/leased
    - Able to host websites as well as carry phone calls
    - Allows continuous, uninterrupted access on Web
  - Cell phone network
    - Wireless network spread over land areas divided into (hexagonal) 'cells'
    - Each cell is served by at least one base station (transceiver), which uses a different frequency range, as compared to adjacent cells, to transmit data
    - Larger capacity possible since same frequencies can be used, in non-adjacent cells
    - Radio waves are usually used for transmission
    - Can be broadcast in all directions over a wide area
    - Portable transceivers (e.g. mobile phones) are able to communicate and access internet via base stations

- IPv4 vs. IPv6

IPv4	IPv6
32 bit address, split into 4 blocks by "."	128 bit address divided into eight 16-bit blocks by ":".
Each block could have a value between 0 and 255 (00 to FF in hex).	Each block can have 4 hex values ranging from 0000 to FFFF
E.g.255.0.1.255	IPv6 can be shortened by removing >=2 blocks containing solely zeroesE.g.2001:0db8:85a3::8a2e:0070:7334

- IPv4 functionality
  - each IP address has 2 parts:
    - Network Identifier (netID)
    - Identifies the network to which the host (device) is connected to
    - Host Identifier (hostID): Identifies the host within the network
  - 'Classfull' addressing used for IPv4 where different bit lengths for identification and impose restrictions on available address
- Subnetting
  - Practice of dividing a network into two or more networks
  - IP addresses are broken down to 3 parts by not changing the netID but partitioning the host ID into a subnet ID and host ID
  - These subnet ID bits are used to identify each subnet within the network.
  - Subnet masks are numbers that hides (masks) the netID of a system's IP address and leaves only the host part as the machine identifier, allowing data to be routed within the subnet to the appropriate host.

- Public and Private IP address
    - Public IP is provided by the ISP while Private IP issued by the LAN's router
    - Public IP is unique and can be across the internet whereas Private IP is only unique within LAN and hence can only be accessed within LAN
    - NAT (Network address translation) required for private IP addresses to access internet directly.
    - Private IP more secure than public IP, since they are not directly accessible on the Internet and are hidden by NAT
    - Range of IP addresses used for private IP addressing can never be assigned to public IP addresses

- Static vs. Dynamic IP addresses

Static	Dynamic
IP address never changes.	IP address will change at regular time periods.
Static IP addresses are useful when websites need to remember a device for a long time. Eg) VPNs whitelisting	Dynamic IP address is relatively more secure, hence used where data privacy is important
Faster upload/download speeds	Maintaining cost of dynamic IP address is lesser

- URL (Uniform Resource Locator)
    - Unique reference address for the exact location of an internet resource on the WWW

$$\underbrace{http://}_{\text{protocol}} \underbrace{commons.\,wikimedia.\,org/}_{\text{hostname}} \underbrace{wiki/File:George\_Clausen\_WWI\_poster.\,jpg}_{\text{location on server}}$$

- Protocol: enables browser to know what protocol is used to access info in domain
- Hostname: Domain name
- Location of server: path
- Domain Name Service (DNS)

    - naming system used for computers or resources having internet connection
    - Consists of a hierarchy of DNS servers which have a URLs database of and their corresponding IP addresses